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All communications should be addressed to the Editor.

No. 96. DECEMBER, 1918. VOL. XXII.

Notices of the Royal Aëronautical Society.

Obituary.

We regret to record the deaths of the following members of the Society:—George Frederick Mort, F.R.S., Associate Fellow, of the New Engine Company.

Second Lieutenant Terence Charles McNeale, R.A.F., who was killed on active service in France on November 9th, 1918.

Air Service Parliamentary Committee.

An Air Service Parliamentary Committee has been formed consisting of Members of Parliament who have served in the Air Force. The Chairman is Captain Wedgwood Benn, D.S.O., D.F.C., and the Secretary, Colonel L'Estrange Malone, R.A.F., Fellow.

Elections.

The following have been elected to the Society in the various grades:—

Fellow.—A. J. Sutton Pippard (1).

Associate Fellows.—C. F. Abell, J. D. Frier, W. D. Douglas, A. Garrard, H. E. Preston, H. L. Stevens, S. Camm, H. J. Pollard, R. B. Elliott, H. Glanert, A. Robertson, R. McKinnon Wood, Lebba Chitty, R. J. Mitchell, H. P. Folland, J. T. Morton, C. G. D. Sandison, E. W. Stedman, J. Morris, A. Winter Moore, H. L. Milner, C. H. Griffiths, A. H. R. Fedden, C. V. Coates, Miss B. M. Cave-Brown-Cave, F. H. Beer, D. McN. Anderson, T. M. Wilson (28).

Members.—G. F. Luke, C. H. Farris, W. P. Lower, S. F. Benson, C. H. C. Smith (5).

Associate Members.—G. Cambling, G. H. Davis, P. R. Roe, A. Warmisham, E. Aspinall, A. Warner Parr, P. Braddock, L. F. Buckingham, K. H. Collinson, S. Jevons Davis, E. G. Ensor, E. A. Greenhill, A. Honey, R. Lea, H. Naltby, R. C. Mitchell, W. H. F.

Murdock, W. E. Ormond, T. H. Plummer, G. H. Russell, P. G. Smales, G. Higgs Walker, C. W. Wood (23).

Students.—J. H. Bentley, R. C. Brand, G. F. Chadderton, P. M. S. Farrington, A. B. Hudson, R. L. Ragg, N. Anderson, F. W. Gee, J. Larne, G. L. Priestley, A. G. Older, J. A. Reeve, S. Saxon, J. Seymour Smith, A. M. Legge, T. Woods Ravenscroft, G. A. Charles, C. H. Luke, A. Malfaison, W. H. Windebank, J. Demprey, J. W. Jagger, L. S. A. Taylor, S. Longhurst, E. Payn, H. G. Luce, F. W. Lemming, W. R. Smith, H. D. Stubbs, G. P. Ford, W. S. Martin, J. V. Green, G. W. Durham, J. C. Kane, S. Riddings, E. A. Newborn, T. Wood, H. Walsh, N. F. Tilbey, E. C. Sterling, F. W. Perrens, R. A. Young, A. Stewart, G. A. Barron, R. F. Bowyer, H. Boyle, A. Cowper, A. D. Hopkinson, H. E. Hudson, S. T. Sanders, W. S. Kilman (51).

Foreign Members.—J. S. Smith, T. Wilson, K. Austin (3). 1,007.

The Membership Roll.

A new edition of the list of members has just been prepared and will be issued to members at an early date. Members will oblige the Secretary by advising him of any inaccuracy.

FIGHTING IN THE AIR.

BY MAJOR COCHRANE PATRICK, D.S.O., R.A.F.

The entire science of aerial fighting has developed, as everyone knows, since the beginning of this war, in other words in the short space of four years.

To-night I am going to attempt to give you an outline of the various stages through which aerial fighting has progressed to its present state of efficiency, though it would be foolish to claim that we have even begun to realise the methods and tactics which will be employed in the future.

All through the history of aerial fighting we find two main governing factors, and I would ask you to notice how these affect each step. These two factors are :—

(1) Field of fire.
(2) Field of view.

In talking of the latter, I shall be constantly mentioning blind spots. By a blind spot is meant anywhere in the sky which is hidden by the planes, tail or fuselage, from the pilot as he sits in his cockpit.

In connection with the first point we have the subject of sights. This subject alone is sufficient for numerous lectures, so that I will only be able to touch upon it to-night. To give you some idea of the difficulties which have been contended with, I would point out that firing and hitting in the air is somewhat akin to shooting a high pheasant with a rifle, one which is doing 100 m.p.h. at that.

I have thought long as to how I could subdivide this lecture in order to make it more clear, but at last decided that it will be best to start at the beginning and go through to the present time, taking each of the points I have mentioned above as they crop up and seeing how again and again they affect the tactics employed and the design of the machines used.

When war broke out the aeroplane as a weapon was an entirely unknown quantity. It was recognised that its value for purposes of reconnaissance would be great. It was believed that it might even be useful to demoralise troops and damage factories by dropping bombs, but the idea of fighting in the air was regarded by most as a wild dream of imagination. The original little flight of machines which crossed to France were ordered, I believe, to ram hostile airships on sight, this being the only satisfactory means of attack which they had. Satisfactory, I should add, from the point of view of the admiring spectator on the ground. I remember being solemnly told when I first joined the R.F.C. (and what is more, I believed it) that the correct procedure on meeting hostile aircraft was this :—If possible overtake him, then dive in front of him and as you passed do a turn. The air pockets caused by this turn, I was assured, would be quite sufficient to send him crashing to the ground.

In the beginning our machines were nearly all of the two-seater type, the few small single-seaters we had (which are known as scouts) were used purely for scouting work, being able to go out, do a reconnaissance, and return very much faster than the two-seaters.

During the first few months of the war machines were allowed to do much as they wished in the air. British and German machines alike carried out reconnaissances and artillery shoots unmolested except by fire from the ground. This did not however suit our Flying Corps; they saw no reason why the German should be given equal chances with ourselves, to gain valuable information, so various methods of attack were tried.

Some attempted to throw rifle grenades or bombs on to a German machine from above, with no success whatever. Others, with better results, flew up to point blank range and used rifles, carbines and revolvers. This, however, was a slow method, requiring a vast expenditure of ammunition as well as a crack shot to bring down a machine. Though, nevertheless, incredible as it may seem, Germans were brought down by a few brilliant or lucky shots. The natural development was the introduction of the machine-gun.

At this point it is well to consider the difficulties of sighting and aiming in the air. In arranging sights for aerial fighting two things have to be taken into consideration :—

(1) The speed of the enemy machine.
(2) The speed of the firer's machine.

I would say here that at all the ranges at which aerial fighting is conducted (which are 200 yards or under) the effect of the forces of gravity and air resistance on the path of the bullet are so slight that they may be entirely neglected.

Let us consider first how the speed of the enemy machine affects the sighting (Fig. 1).

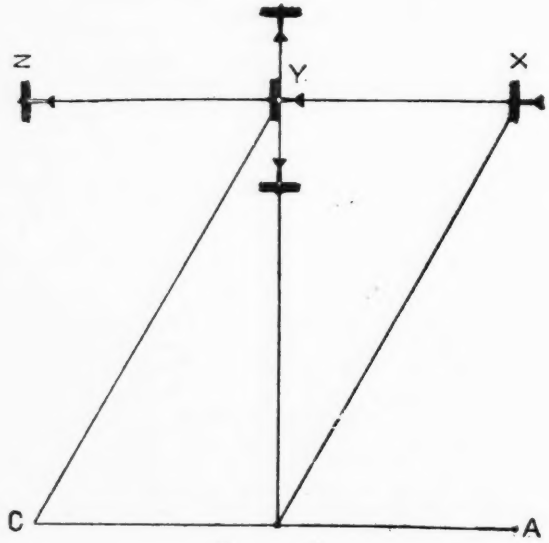


FIG. 1.—A.

Consider the firer to be stationary at B, the enemy machine to be flying across his front along the line XYZ. The firer will have to aim a certain distance ahead of the machine in order to hit it, owing to the time it takes the bullet to travel a certain distance after the trigger is pulled. At 200 yards, as a matter of fact, with a machine doing 100 m.p.h. at right angles to the line of fire, it is necessary to aim 40 feet ahead of a machine.

This means that if a firer at B points his gun directly at a crossing machine at Y, by the time the bullet reaches Y the machine will be at Z. If, however, he fires at Y when the machine is at X the bullet will hit the machine at Y if XY = 40ft. and BY = 200 yards.

If, however, the enemy machine is flying directly along the line YB, either

towards or away from the firer, he will hit it if he aims straight at it as the line of flight of the bullet is the same as that of the machine.

Let us now reverse the process and put the firer in the machine firing at a stationary target at B. The bullet will have two velocities acting upon it, that towards B given by the force of explosion and a velocity sideways given by the speed of the machine.

In other words, if the firer is at Y and he point his gun at B and fire, the bullet will be carried sideways and will end up at C. To hit B he will have to fire at A.

If, however, the firer's machine is flying either directly towards or directly away from the target, he will be able to aim straight at it, as the velocity imparted by the speed of the machine and that imparted by the explosion are along the same line YB.

It will be understood that for every angle of approach or departure of an enemy machine, and for every different angle which the firer's gun makes with the line of flight of his machine, an apparently different allowance must be made in aim. This allowance is called the deflection, because it is the amount the line of sight must be deflected from the line of fire. I would ask you to remember that word carefully as it will occur whenever we mention sights. "Deflection" is the distance it is necessary to aim off a machine in order to hit it.

The above is a very rough outline indeed of the problems in aerial sighting. It is naturally very much more difficult when both the firer's machine and the target machine are moving. Let us now go back. We will find three types of machines in use:—

The tractor two-seater.
The pusher two-seater.
The tractor scout.

We find also the Hun flying about more or less unmolested and we find a light machine-gun being introduced. It will be seen that for offence it is necessary to fire forwards, as one cannot attack while running away. Firing forwards in a tractor machine, however, was impossible, as the propeller prohibited this, owing to the danger of hitting it. The best that could be done was to set the gun at an angle so as just to miss the propeller. This necessitated a sort of sideways attack and brought in all sorts of complications in sighting owing to the gun firing at an angle to the line of flight. A few scientific minds worked out the amount of deflection the angle of their gun would necessitate on their machines and set the sights accordingly. Notable among these was Major Hawker, V.C., who mounted his gun on a fast single-seater, which was probably the forerunner of all our modern fighting machines. This method was very unsatisfactory, however; it was especially so in two-seater machines where a movable gun was worked by an observer, owing to the fact that as the gun moved so the deflection allowance for the speed of the firer's machine altered. Moreover, the field of fire was very restricted.

The choice for fighter machines then naturally fell on the pusher type two-seater. Here was an unlimited field of fire and view forwards, the pilot manœuvred the machine, the observer did the shooting. So our first successful fighting machines were of this type, and aerial fighting came to stay.

Designers both in England and Germany then set to work to build machines solely for the purpose of fighting, and it became evident that the side which could drive off and shoot down the enemy's reconnaissance and artillery machines while protecting its own would be at an enormous advantage.

The single-seater appeared the best type of machine owing to the fact that it could overtake and out-manœuvre the enemy's larger aircraft, but the pilot having only one pair of hands could not both manage the machine and aim and fire the gun. This difficulty was overcome by attaching the gun rigidly to the machine. In order to aim the gun the pilot had to aim the whole machine by means of his flying controls. This is not such a difficult matter as it sounds as machines are very sensitive on the controls—a very slight movement altering the line of sight as much as twenty degrees in a fraction of a second.

The next difficulty was the allowance for deflection owing to the speed of the firer's machine. It has been pointed out that if the gun fires parallel with the line of flight of the machine no allowance for deflection was necessary. By designing for this another problem would be solved.

We have now requirements:—A single-seater with fixed gun firing ahead and parallel to the line of flight of the machine for purposes of attack. With a tractor type of single-seater this meant firing through the propeller, which revolves at anything up to 1,600 rev. p.m. without hitting it.

The French were first to achieve this by fixing large steel deflectors on to the propeller blades where they passed opposite the barrel of the gun. These deflected any bullet which struck them, but they also impaired the efficiency of the propeller so much that only one type of machine was ever fitted with them.

The Germans were the next to produce a satisfactory arrangement; this they incorporated in the famous Fokker monoplane, which was the first German machine built solely for fighting that appeared in any quantity on the line.

The German method was to employ a synchronising gear. The general idea is that instead of the firer pulling the trigger a gear connected with the engine pulls it at the right moment. The firer controls the gun by throwing the gear in or out of action. The gear, when in action, pulls the trigger every time a propeller blade comes directly in front of the barrel. The delay in priming the cartridge and exploding the charge gives the propeller blade just time to get out of the way before the bullet passes, thus ensuring that the blade is not hit. The advent of the Fokker marks a very distinct stage in the history of aerial warfare. It was the first attempt on either side to gain definite control of the air. Until then fights were few and far between, no definite tactics were used, and formations of machines were practically unseen except where a large number of bombs had to be dropped. The Fokker's tactics were simple at first, they would climb up towards the sun and wait till one of our artillery machines came along intent on the work in hand. Then came a sudden dive, a burst of fire from behind the British machine, and in many cases a bullet through the British pilot's head before he knew where the shots were coming from (Fig. 2). The most common British two-seater at that time was one which had been designed on pre-war lines with the passenger in front. You will see how cramped a position he occupies. Field of fire forwards blocked by the propeller, to the side by the planes and struts, in fact the only good shot he can get is by kneeling on his seat and firing back over the pilot's head.

To understand the Fokker's tactics (Fig. 3) we must remember that so far no satisfactory sight has been brought out which allows for the deflection necessary for the speed of the target machine. He has got over the difficulty as regards the deflection for his own speed by firing straight through the propeller on his own line of flight. He now attempts to get over the necessity for allowing deflection for the British machine by diving from behind and firing in the line of flight of the British machine. The Fokker was not a very handy machine, and our pilots soon found that by turning they could avoid the enemy's line of fire while exposing the Fokker to fire from their observer's back gun. In consequence the Fokker pilots took to making one dive on our machines. If they did not succeed on the

FIG. 2.—B.E. WITH GUNS.

FIG. 3.—FOKKER.

FIG. 5.—PUSHER SCOUT.

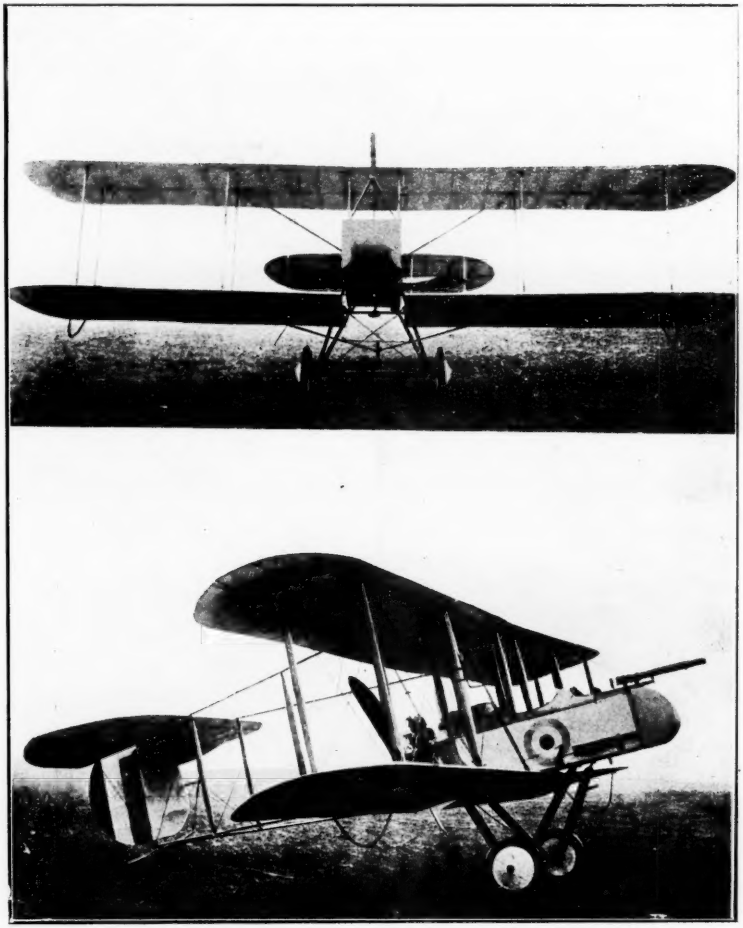


FIG. 4.—PUSHER TWO-SEATER, SIDE AND FRONT.

FIG. 6.—NIEUPORT SCOUT.

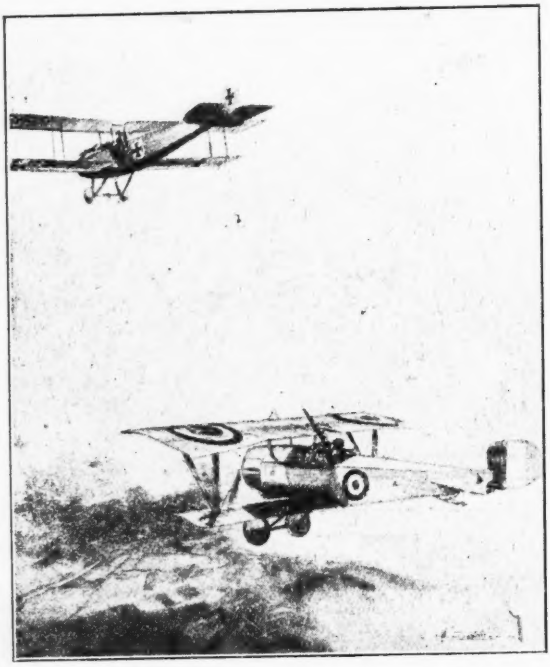


FIG. 7.—NIEUPORT AND HUN.

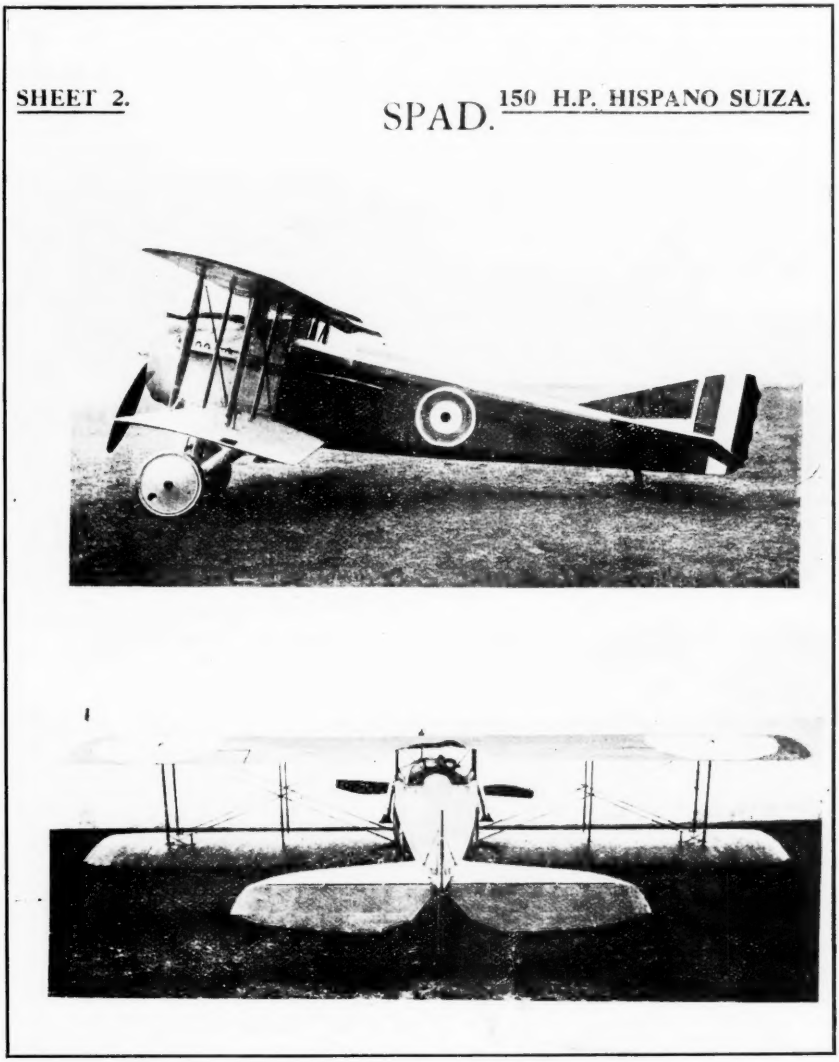
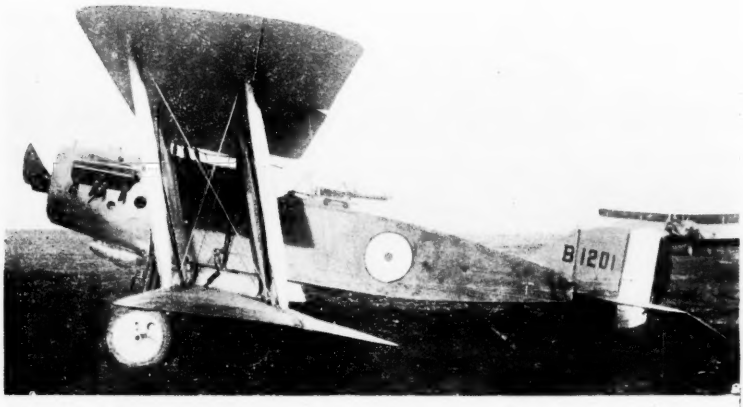


FIG. 8.—SPAD, BACK AND SIDE.

FIG. 9.—RICHTOFEN'S CIRCUS.

SHEET 2. 200 H.P. HISPANO-SUIZA BRAZIE

BRISTOL FIGHTER No. B. 1201.



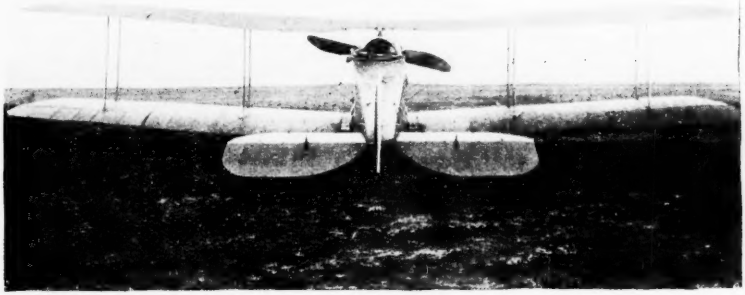


FIG. 10.—BRISTOL FIGHTER, BACK AND SIDE.

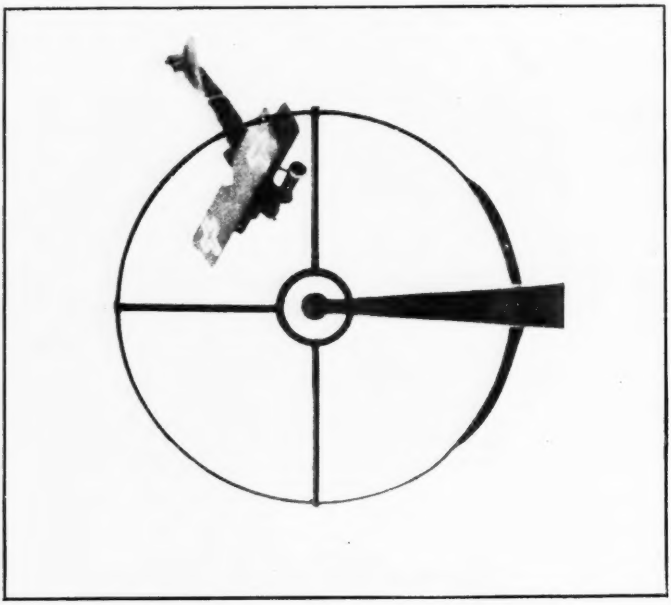


FIG. 14.

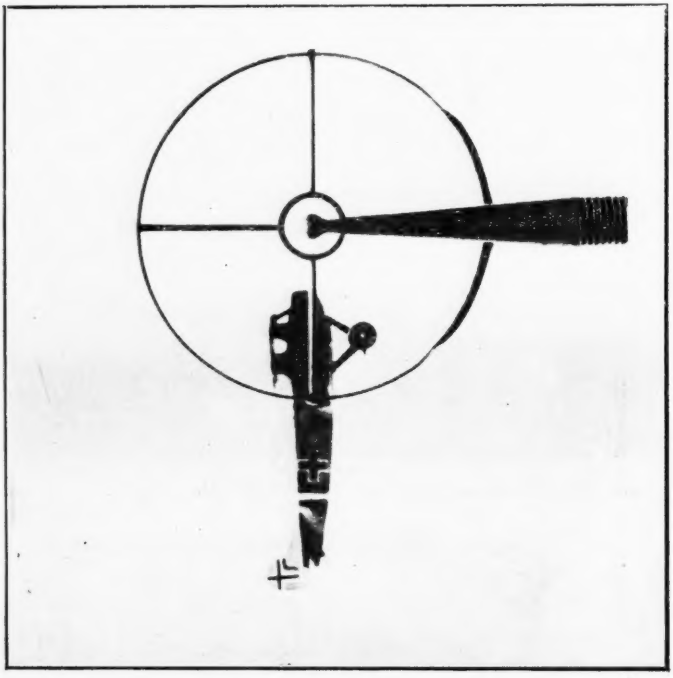


FIG. 13.

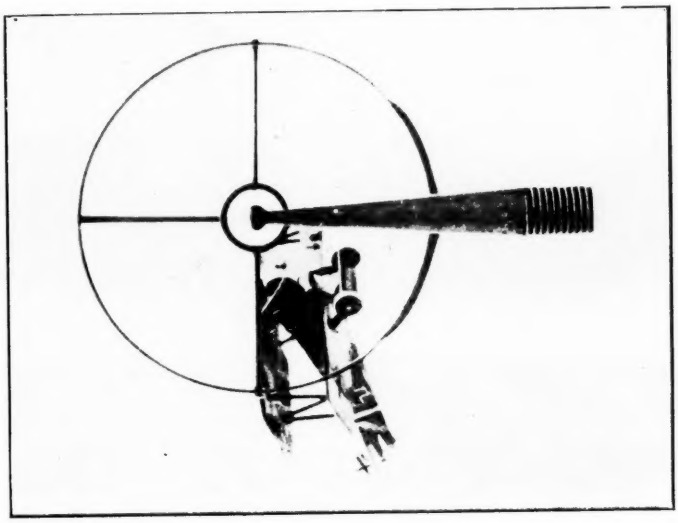


FIG. 16.

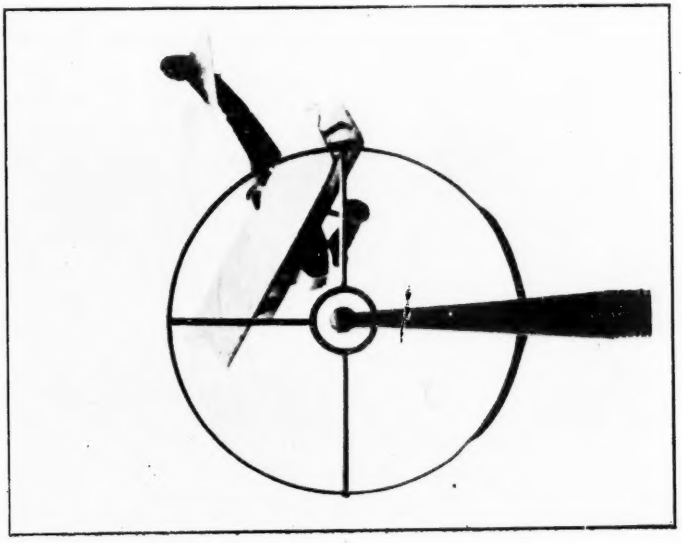


FIG. 15.

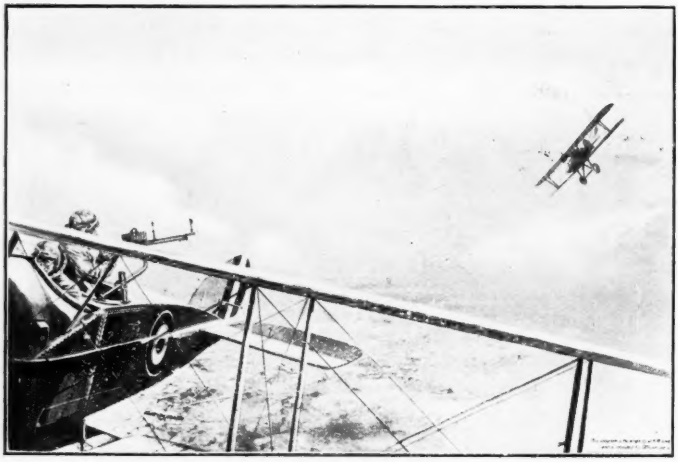


FIG. 17.—HUN IN THE SUN.

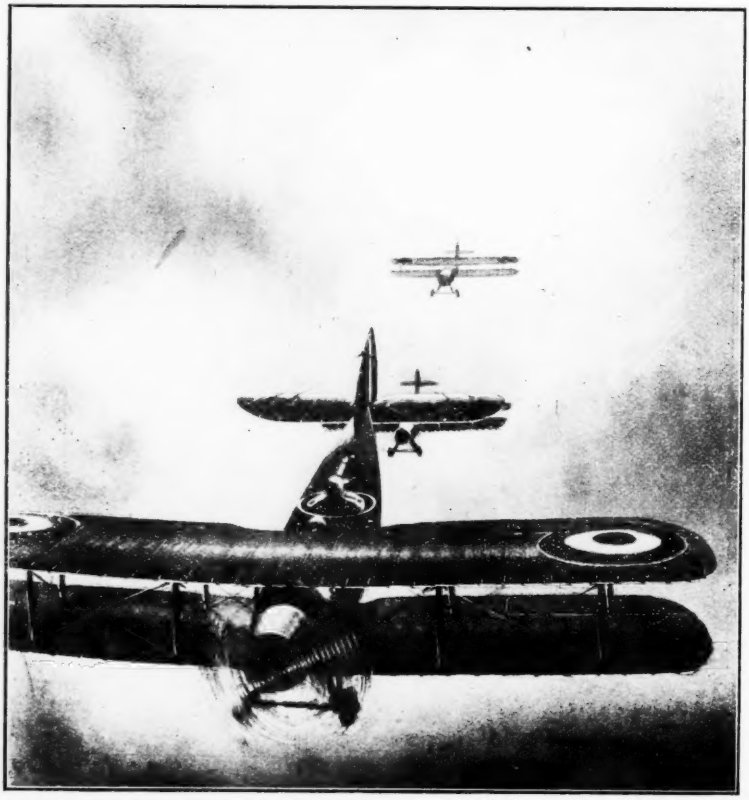


FIG. 18.—VIEW FROM OBSERVER'S SEAT.

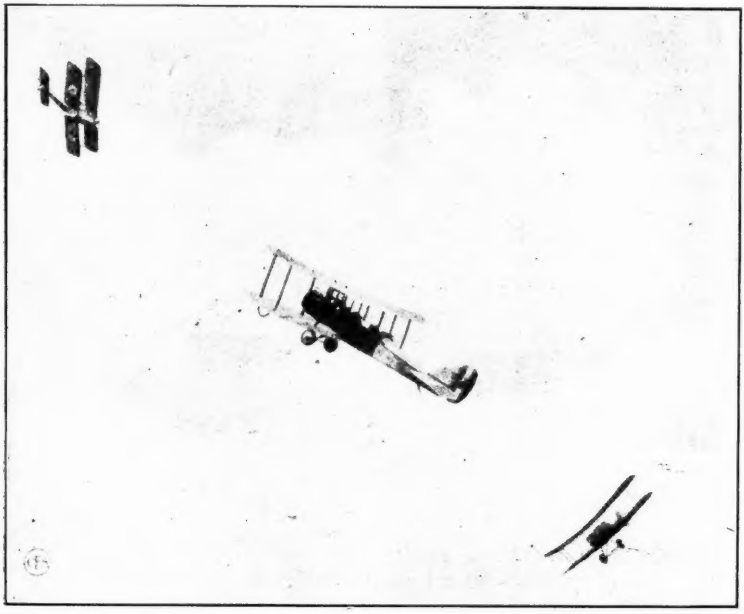


FIG. 19.—TWO SCOUTS ATTACKING A TWO-SEATER.

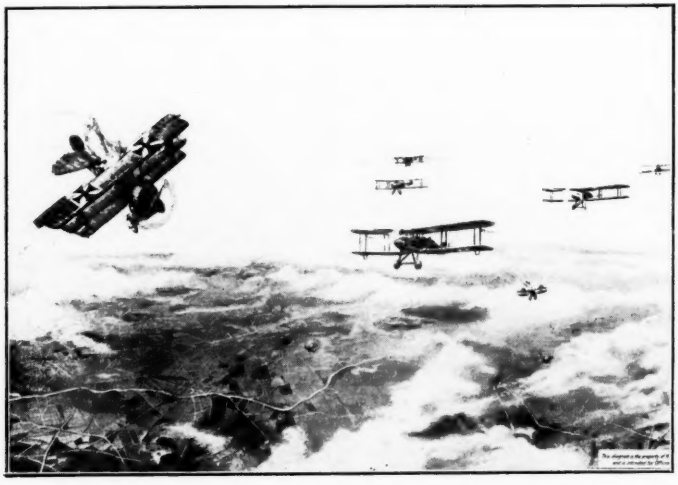


FIG. 20.—FORMATION *v.* HUNS.

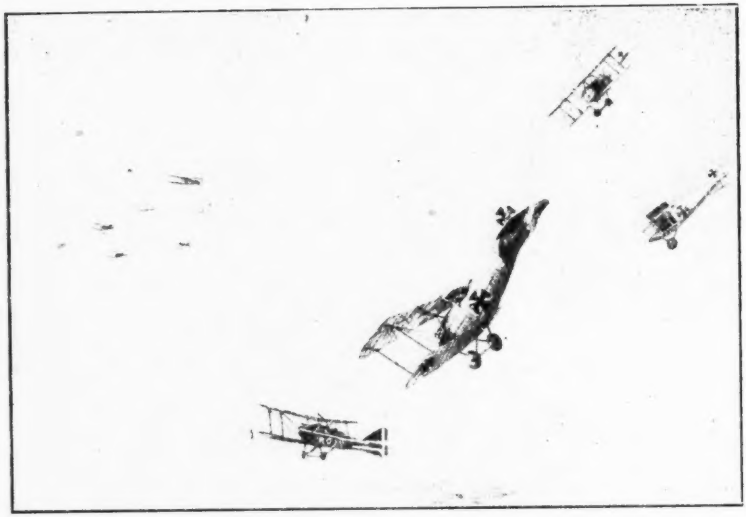


FIG. 21.—THE CONSEQUENCE OF LOSING FORMATION.

first dive they carried right on till out of range and flew home. However, for a time the Fokker was a decided nuisance as our observers were compelled to keep a constant look out instead of attending to the job in hand. The next development was the escort machine. Instead of sending out one machine alone, as formerly, we sent two, one to do the artillery shoot or reconnaissance, the other flying slightly above to keep a close watch for Fokkers and to fight them off when attacked, thus allowing its comrade to do his job unmolested.

The Germans reply was to attack with two or three Fokkers at a time. This brings us to the end of 1915.

Let us just review the situation. On our side a few two-seater fighting machines of the pusher type, also a few tractor scout machines with guns firing either at an angle or through a propeller with deflectors. These, however, were not numerous enough to act more than one at a time. In consequence our two-seater artillery and reconnaissance machines are compelled to work in formation of two or more, one machine doing the work, the remainder the escort.

The beginning of 1916 sees a great change. Our designers have meantime been working on the problem of fighter machines and have decided for the pusher type. In consequence we see several new squadrons detailed purely for fighting, and consisting of two-seater machines of a superior type to our former ones, and small fast single-seater pushers. With these machines we find a splendid field of view in front, a gun firing straight along the line of flight as there is no propeller in front to trouble about, and a superior manœuvrability and performance to the Fokker. Owing to the arrangement of separate units doing the fighting and artillery work it was found most satisfactory to arrange for protection for the latter by a system of patrols. A section of the line would be allotted to each fighting squadron for a certain time of day. The squadron concerned would arrange to patrol this sector and keep it clear of enemy aircraft for the time allotted.

This arrangement was found very satisfactory, it served a dual purpose. The patrols by keeping the line clear of enemy fighters ensured that our artillery machines did their work unmolested, they also attacked and drove off or shot down any enemy artillery or reconnaissance machine who tried to work in their turn.

When a bomb raid was made some distance over the lines out of range of the protection of these patrols, an escort of fighting machines would be arranged for to protect the slower bombing machines.

From this point to the present time the general tactics have altered hardly at all except in the matter of escorts, so I will outline them once again.

By a series of patrols on definite sectors all down the line our fighting squadrons endeavour to keep the air clear of German machines from five to ten miles over the line. Under cover of these patrols our artillery and short reconnaissance machines work, and it is in constant danger from these patrols that the German does his artillery and reconnaissance flights.

From here I will be able to confine myself to the detailed tactics of patrols, but you will understand that when I talk of fights and tactics of scout machines they nearly all take place on these patrols to keep the line clear.

During the first part of 1916 then we have for the first time aerial forces acting against each other whose sole business is fighting. On the ground the centre and *raison d'etre* of an army is the fighting man—the man who is there solely to kill. Every branch works to help him and to make the killing of greater numbers easier to him. In the air, on the other hand, at present the hub, so to speak, is the reconnaissance and artillery machine, the fighter is merely there

to help and protect these latter while they do their job and to hinder the enemy's artillery and reconnaissance machines from doing theirs. In order to do this efficiently, however, the fighter must first drive off or kill the enemy's fighters.

We have seen the development of formations owing to the necessity for an escort. We have seen the German's reply by attacking with formations of fighters. We now come to our original governing factors making themselves felt and being yet another powerful reason to cause the adaptation of formation fighting, field of fire and field of view. We have seen how the Fokker endeavoured to overcome the deflection difficulty in aiming by attacking from behind and firing along the target machine's line of flight (Fig. 4). We now found that the pusher type of fighter gave these tactics too many chances to make it pleasant for a lone pusher to be caught by two or three Fokkers. Not only was the observer's field of fire behind absolutely cut off by the planes, propeller, etc., but in too many cases the Fokker approached unseen, owing to the large blind spot behind and above the top plane. In the pusher scout (Fig. 5) the loss of field of fire did not apply, as owing to its very superior manœuvrability it could turn and bring its gun to bear very easily, but the field of view was a serious drawback, as the pilot had to do all the looking out for himself, having no observer to help him.

The consequence was the universal adoption of formation. There is never a point in the sky which some member of a formation cannot see, also if one man gets a Hun on his tail, as the saying is, another in the formation will see and shoot him off.

The next development in fighter machines was French (Fig. 6). It was a tractor single-seater with, for those days, a very fine performance.

The methods employed to solve the various problems which we have already met with were highly ingenious. We will take first field of view. As you see, the pilot is seated behind the top plane. The view behind, except under the tail, is unhampered. His head is rather lower than the top plane, but by standing up he can see over it, so that there is only a very small blind spot above and in front. Looking over the side we find a very narrow bottom plane, so small that a very slight kick on the rudder will swing it out of the way and we can see everything below. Next we have the difficulty of firing forward. This is got over by mounting the gun quite high on the top plane so that it just shoots over the top of the propeller. It is set at a slight angle upwards from the line of flight, but this is not enough to introduce complications in aiming.

When in this position the trigger is pulled by a Bowden cable running down to the control lever. The gun can also be pulled down so as to fire upwards at a steep angle (Fig. 7). This method was used much by Captain Ball, V.C., and was originally his favourite method of attack. In this case again it is a point blank shot as both machines are travelling on parallel lines of flight at approximately the same speed.

At about the same time as this scout the forerunner of the present two-seater made its appearance. The machine was a tractor. Many lessons had been learnt and the result was that the pilot was put in front and the observer behind. Where an enemy could not be shaken off from behind by quick manœuvring a man had to be put to shoot him down. The observer being behind the planes his field of fire forwards was practically nil, so that the pilot was given a gun firing through the propeller by means of a gear which he used in much the same way as a scout pilot uses his gun.

These machines made up in field of fire what they lost in manœuvrability, and it is still quite a debated point as to whether a two-seater thus armed is more than a match for a scout machine or not.

These machines were quite capable of looking after themselves, so we find the necessity for escorts of fighting machines going with long bomb raids or reconnaissances becoming less and less and scout machines confining themselves to the ordinary work of patrols.

I will now divide the remainder of my time into three parts and deal shortly with the development from this stage of—

(1) Design of machines.
(2) Design of sights.
(3) Fighting tactics.

I will first show you a more or less typical scout machine (Fig. 8). The method of shooting through the propeller by means of a gear was universally adopted. In order to increase the rate of fire two guns were put on scouts firing simultaneously.

This was found necessary owing to the extremely fleeting chances of a shot which are possible to be got in a fight. When machines are manœuvring around each other at approximately 100 m.p.h. targets remain in a favourable position only for a matter of seconds and therefore it is necessary to fire as many bullets at him as you can in those seconds. You will see the gun under the centre section just in front of the pilot where he can get at it to remedy any temporary stoppages.

The top plane is almost level with his head and therefore his view above and forward is almost entirely unobstructed.

The view directly above is more important in a fight than would appear at first sight.

Imagine two machines manœuvring round one another for position, each trying to turn faster than the other in order to get behind the enemy's tail. They are both on an almost vertical bank and on opposite sides of a circle. One or other will tire sooner or later and will try some fresh manœuvre, and it is of vital importance to see the start of any such manœuvre on the enemy's part.

(Fig. 9.) Here we see a picture of Richtofen's famous circus. You will notice that these machines incorporate much the same features. Pilot behind and almost level with the top plane, two guns, etc.

(Fig. 10.) Here is a typical two-seater fighter of to-day. You will see that the same position is adopted for the pilot as in the scouts we have seen already. The observer is placed behind and close up to his pilot so that he may communicate with him by touch in a flight. You will see what a splendid field of fire he has all around, both in front over the top plane and behind, in fact the only blind spot which he cannot reach behind is under the tail.

The pilot looks after the front, he has a gun mounted as we saw in the scout firing straight forward through the propeller.

Since the beginning of 1917 practically the only difference in design of fighting machines has been in increased speed climb or manœuvrability, the general features being as I have shown you, so that these machines will serve as examples of the machines in which we use the sights and the tactics which I will now describe to you.

The two problems in sighting were:—

(1) To allow for the deflection in aim necessitated by the speed of the firer's own machine.
(2) To allow correct deflection for the enemy's machine.

We have seen how in the scout machine the first of these two problems was solved by firing straight forward along the line of flight. The second problem was also circumvented provided the attacker could get into a favourable position directly behind the enemy's tail and fire straight down his fuselage along the enemy's line of flight. But this position was a difficult one to get, requiring skilful manœuvring and only allowing a fleeting chance of a shot owing to the very fact that no man would allow an enemy to remain in such a favourable position for longer than he could possibly help.

So many brains started to work on the problem. (Fig. 11.) Here again we see an enemy machine crossing at right angles at X. The firer's gun is AB, A being the usual backsight and B the foresight. A bullet, therefore, if fired from this gun will travel along BC.

Now we know the speed of a bullet and we know approximately the speed of an enemy machine. If the enemy is travelling at 100 m.p.h. he will cover 40ft. while the bullet is travelling 200 yards. Let XC then equal 40ft. and BC 200 yards. If the trigger is pulled when the enemy is at X he and the bullet will meet at C. We have therefore to arrange for some form of sight to help us. If we prolong the sight line XB through the foresight B to K on an arm A, K sticking out at right angles to the gun and put the backsight at K we have a sight which will cater for machines crossing at right angles from left to right.

Let us now take the case of a machine Y approaching at an angle along YC. BC is still 200 yards, so if we want to hit the machine at C we must pull the trigger when the machine is at Y with YC = 40ft.

Again, prolong the sight line YB through B to I, a sight on an arm AI parallel to YC the line of flight of the machine, put the backsight at I and you have the necessary sight. Now XCB and KAB are similar triangles, but so are YCB and IAB. XC and YC are equal, *i.e.*, 40ft., therefore AK and AI are equal, therefore we need not make a separate arm AI. If we arrange AK to pivot at A and swing it round parallel to the line of flight of the enemy it will give correct allowance for any angle of approach.

That is correct for 200 yards. It is also correct for any range. Take the cases of W and Z approaching on parallel lines of flight to X and Y but only two-thirds the distance away. If we use this sight we will press the trigger when they cross the lines XB and YB respectively. Now BD is $\frac{2}{3}$ BC, therefore the bullet takes $\frac{2}{3}$ the time to get to D that it did to C. But WDB and XCB are similar triangles, so are ZDB and YCB, so that WD and DZ are $\frac{2}{3}$ XC and YC, therefore the machines W and Z take $\frac{2}{3}$ the time getting to D that X and Y took getting to C, therefore again the bullet hits them at D. In the same way this form of sight is correct for any range used at present in aerial fighting. As long as the length AB from backsight to foresight is known it is quite easy to work out the necessary length of the arm AK.

So the first attempts at making sights which would allow correct deflection for the enemy machine were all in the form of short arms set at a definite distance behind the foresight and pivoting on a universal joint. These arms carried the backsight and had in all cases to be set parallel to the line of flight of the enemy machine by the firer. This meant that he had to devote the use of a hand which was already fully employed to the sight, that he had to judge the exact angle of the line of flight of the enemy machine, a much more difficult matter than would at first appear, and that if he should get into a close fight he would have to judge the angle, adjust the sight, aim and fire all in a matter of seconds. This form of sight was used however for some time, but was not found to give good results.

The sight which we are still using was then brought in.

(Fig. 12.) Here again we have an enemy at X flying across a firer's front at right angles. The gun is AB. Again we will take that XC is 40ft., BC = 200 yards.

In order to hit the enemy at C, if the firer's eye is at A, he will sight along the line AX. If we put a right angle bar across the foresight ending at E and D this will give him the correct line for right angle shots.

Now if with centre C and radius equal to CX 40ft. we describe a circle, any machine on the circumference of this circle, when the trigger is pulled, will be hit at C, provided its line of flight passes through C. This also applies on the vertical plane.

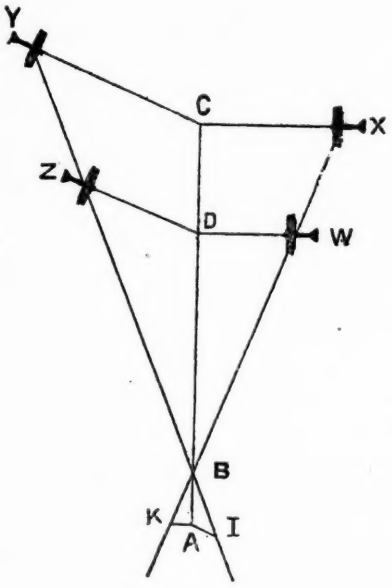


FIG. 11.—B.

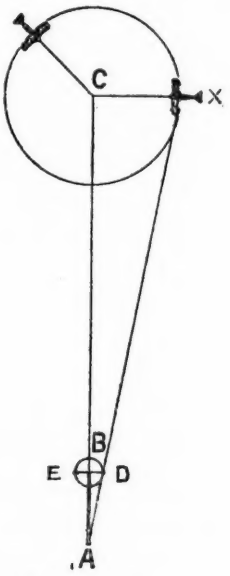


FIG. 12.—C.

This gives us the ring sight. It is a ring of radius BE, which length depends on the length AB, mounted on a convenient place the correct distance from the firer's eye. In order to ensure that the firer's eye is on the correct line ABC a bead is placed somewhere between AB on that line.

This gives the firer a definite aiming point for all right angle shots, diving, climbing, or flying level.

For shots at machines coming in at an angle the firer imagines his ring to be a glass ball and places the enemy machine on its circumference pointing into the centre.

With this sight no adjustment is necessary and with constant practice it becomes fairly easy to place machines in the correct position in the ring to obtain a hit.

This is a very short explanation of the ring sight and I am afraid not very clear. Here we have some instances.

(Fig. 13) Here we see a Fokker biplane crossing at right angles at close range. You will see the bead I mentioned in line with the centre of the ring. The edge of the ring is cutting the pilot's seat, which is just behind the plane, so that we should hit the pilot himself.

Here (Fig. 14) we see the German diving across our front at an angle. If you can imagine the ring as a glass ball you will see how again the outside of the ball cuts through the pilot's seat. The German is at 150 yards in this picture. Now (Fig. 15) he is only 75 yards away; but again you see the pilot's seat is on the outside circumference of the ball. In (Fig. 16) this picture we have another aspect.

Thus we have a sight which guides us in allowing the correct deflection for an enemy machine; we abolish the deflection due to the speed of the firer's machine in the case of the pilot by placing his gun so that it fires parallel to the line of flight.

This leaves us with the problem of the observer's sight only.

He of necessity must fire at all angles to the line of flight.

You will remember how by putting an arm pivoting on a universal joint which was set parallel to the line of flight of the enemy machine we got a theoretically accurate allowance (Fig. 11).

This in effect was done for the observer's gun. By mounting an arm of the correct length on a universal joint with the foresight on one end and a wind wave behind this arm was always kept parallel to the line of flight of the firer's machine by the action of the air on the wind vane, thus making the necessary allowance automatically. This covers very sketchily the question of sights. We will now deal with a very few of the points in aerial tactics.

In all forms of attack surprise is a most valuable factor. With this end in view the air fighter uses to help him sun, clouds, the blind spots of the enemy's machine, and many other aids.

A machine in the air is at all times very difficult to see. Watchers on the ground often cannot understand why formations do not see each other.

This, of course, is due to the fact that from below a machine is always seen as a silhouette, a black object against a background of light.

From above, however, a machine is seen against the brown and green background of the earth. It is possible by means of good camouflage to make a machine absolutely invisible, and the only thing which gives it away is its movement.

The sun again is of great assistance to the stalker. Here (Fig. 17) we see an instance. You know how it dazzles you to look in the sun. The German on the left here has taken advantage of that. He has got in between the observer and the sun, and it looks as if our observer had lost sight of him altogether.

Again, on a hazy day there is a curiously sharp horizon line, which appears to keep level with you, made by the top layer of the mist. Machines approaching level with you on these days are very hard to see. Their planes only appear as two thin lines which seem to merge with the horizon line.

Clouds, too, are of great help to the stalker. I remember one day when Major Bishop, V.C., was out by himself stalking Germans amongst the clouds he saw two Hun scouts of an old type flying most temptingly below a hole in one of the largest cloud banks. He at once dived upon them, but before he had gone far his suspicions were suddeuly aroused by the apparent idiocity of two such

obsolete machines thus leaving themselves open to attack. So he climbed back hurriedly into the clouds above. As he came out on top he was just in time to see the last of three machines, the enemy's latest type fighters, diving through the hole, hoping to catch him attacking the two old decoy machines. Again Bishop dived, this time with no misgivings, and one after another the three Germans fell in flames.

Clouds are especially useful for attacking enemy balloons. A day when the clouds are thick and low is usually chosen. The pilot flies up just behind our lines and takes a rough bearing of the direction in which he has to fly to reach the enemy balloon. Then he climbs into the clouds and steers by compass for a certain time, which he has previously worked out, according to the distance the balloon is over the lines. He dives; and before the astonished gunners, whose business it is to protect the balloon, have time to sight accurately, he has fired his bullets and is back again into the clouds heading for home.

Another method of attack is that from the east. This requires patience, and careful study of the Hun and his ways. The scout hiding up in the sun, or behind some clouds, sees an enemy two-seater coming towards the line. For a few minutes the Hun is nervous, flying up and down looking for enemy machines. Then, seeing none, he settles down to the work in hand—reconnaissance or artillery observation on our side of the line. Though he may keep a good look out for enemy machines, he looks to the west, and not behind him over his own lines. This gives the scout his opportunity. He approaches from the enemy's side. To do this he has often to make a long detour over the enemy lines, to avoid frightening his prey (Fig. 7.) Here we see him just before he opens fire. The German observer is looking ahead over the side, quite unconscious of the scout below his tail. Even when he hears the shots he will probably not be able to retaliate, as his tail hides the scout from view.

(Fig. 18.) Here we see a view from above which illustrates this. The pilot will have to turn slightly, swinging his tail out of the way to enable the observer to shoot. He has done this in Fig. 19, and the observer now can get a shot at the attacker on the right. But meanwhile he is being attacked from the left front by another scout. You remember that the pilot's gun is fixed and only fires straightforward. To bring it to bear upon the scout ahead he will have to swing to the left again, giving his second opponent an opportunity to get under his tail.

A formation of two-seaters, however, is a very different proposition to tackle (Fig. 20). Enemy scouts attacking from any direction come under fire, either from the pilot's or observer's guns, from at least half the machines in the formation. Even scout machines must be wary of losing formation. (Fig. 21.) Here we see a scout who, probably owing to a faulty engine, has had to drop back out of formation. Three Germans who have been waiting high up above to pick off stragglers have seen him and swooped down to attack.

These are a few of the points which the fighter in the air has to learn to watch for. As in everything else, proficiency comes only with constant practice. Unfortunately only too many die while yet learning, but everything possible is done to train our new pilots in the tactics of aerial warfare before they cross the lines to meet the German.

PROCEEDINGS.

FIRST MEETING, 54th SESSION.

The First Meeting of the 54th Session of the Royal Aëronautical Society was held at the Central Hall, Westminster, on Thursday, November 8th, Major-General Brancker, R.A., presiding.

Major-General R. M. Ruck, C.B., R.E., President of the Society, in opening the proceedings, asked those present to join him in an expression of regret at the untimely death of Captain B. C. Hucks, R.A.F., who was well known to a great many members of the Society and had come and assisted the Society on many occasions. He would like to allude to Captain Hucks' unusual combination of qualities, in that he was not only a daring and gallant pilot, but also a man of very superior intelligence and resource, which was very important in the development of aeronautics.

Major-General W. S. Brancker, R.A., said the Society, for the last four years, had been somewhat cramped in its activities. It was a peaceful Society, and had not had much of a chance during the war, but now that peace was almost upon us he thought we could hope that its responsibilities would be vastly increased, compared to what they had been during the past four years, and the Society would have a great opportunity of stepping in and helping in the development of peaceful and commercial aviation in the future. It might be urged that at this particular moment it was hardly fitting to have a subject like "Fighting in the Air" as the first lecture of the session. At this moment—one of the most historic moments in the world's history—it might be thought we should rather be talking about commercial aviation and its development, and the application of aviation to improve the conditions of civilisation, and thinking about how we were going to make money, how we were going to make aviation safe, and how we were going to make it apply to the millennium which was coming, when the lamb and the wolf were going to lie down peacefully together. He disagreed; he thought this was the moment to consider and sum up the wonderful development of fighting in the air. This art was the product of war, and it had reached a pitch of perfection which scarcely anybody had dared to think of five years ago, and, having attained its zenith and accomplished its end, it was threatened with the fate of steadily declining and eventual extinction, unless some artificial means were developed of preserving the great fighting spirit and extraordinary ability which were necessary in the fighting pilot. We had it now, and it was up to us to keep it, so that true peace might be assured. Not long ago there were many who said the war would be won in the air. He was one of them. He went to America and talked a great deal on the subject, but not one of the things he said had come true. He said we were going to fly the Atlantic and bomb Berlin before the end of the war, but since the beginning of July we had had an unbroken chain of success on the front, and were winning the war by the sheer power of the infantry. He doubted, however, if the majority of people realised what an important factor aviation had been in winning these battles. Our supremacy in the air had been one of the most vital factors in our success, and particularly our undisputed supremacy in air fighting; the Germans had not been able to touch us this year. He granted that the Armies realised what they owed to the Air Force in the victories they had just won. He hoped this lecture would enable those present to realise the extraordinary possibilities of aerial fighting

in the future and the absolute necessity of maintaining efficiency in that particular branch.

Major Cochrane Patrick, D.S.O., R.A.F., then delivered his lecture, "Fighting in the Air."

Major-General Brancker, in moving a vote of thanks to the Lecturer, said he was sorry the latter had cast reflections on the training they had in the Air Force, for which he (General Brancker) was responsible, and, to do the War Office justice, he read the following extract from the Manual of the R.F.C., which was published early in 1914:—

> "It is probable that one phase of the struggle for the command of the air will resolve itself into a series of combats between individual aeroplanes or pairs of aeroplanes. If the pilots of one side can succeed in obtaining victory in a succession of such combats they will establish a moral ascendancy over the surviving pilots of the enemy and be left free to carry out their duties of reconnaissance. The actual tactics adopted must depend on the types of the aeroplanes engaged, the object of the pilot being to obtain for his passenger the free use of his own weapon while denying to the enemy the use of his. To disable the pilot of the opposing aeroplane will be the first object. In the case of fast reconnaissance aeroplanes it will often be advisable to avoid fighting, in order to carry out a mission or to deliver information, but it must be borne in mind that this will sometimes be impossible, and that, as in every other class of fighting, a fixed determination to attack and win will be the surest road to victory."

Some people had at that time far greater dreams of the future of aerial fighting, most of which had come true. The present moment was one of the most interesting, but one of the most dangerous in the history of aviation. After 4½ years' unlimited expenditure of money and of development, rushed on by the urgent demands of the leaders in the field, we had a huge and delicate machine, the R.A.F. (which was still in its teething troubles), and we had, behind it, a vast and efficient aircraft industry, and we were confronted with the task of converting this great organisation with as little dislocation as possible to the uses of peace. We must preserve our aircraft industry at all costs, as it was going to be our greatest and cheapest insurance against war in the future. At the moment it looked as if there would be a large measure of disarmament, and it was doubtful whether any government could go on devoting large sums of money to maintaining a large aerial fleet. We had to make commercial aviation a success, and it must be so developed that it would eventualy give us, rapidly and easily, an efficient weapon in the hour of need if war were again thrust upon civilisation. It would be difficult to preserve the activities of the Air Force, which were useful for war alone. He had hopes that well-organised and remunerative aerial races and aerial acrobatic displays might help to preserve the skill we had obtained at the cost of so much blood and money, and also to develop the designs which would outrival in power and speed those of any other nation. The burden of maintaining the fighting spirit must lie with the Royal Air Force, and the other factors the manufacturers could be relied upon to produce—perhaps with a great deal of unnecessary Government interference. Lord Weir contemplated asking all the British aircraft manufacturers to meet the Air Council and talk about some of the burning questions in connection with the development of commercial aviation.

Major-General Ruck, in proposing a vote of thanks to General Brancker for presiding, said he hoped members would attend in as great force as possible the other lectures of the session. The membership of the Society had increased from about 300 (with an income of a little over £300 per annum) two years ago to over 900 (with an income of about £3,000) this year. They still invited new

members. He, like General Brancker and others, had made forecasts about the war finishing in the air, but he took consolation in the fact that General Allenby's success in giving in Palestine the final push which brought down the whole German fabric was largely due to the assistance of aircraft, and he thought they might reason from that that they were right in their prophecies. He congratulated General Brancker on his rapid promotion during the war, and they all appreciated the distinguished part he had played in the development, administration, and organisation of our splendid fighting Service.

PROCEEDINGS.

FIFTH MEETING, 54th SESSION.

The Fifth Meeting of the Session was held at the Central Hall, Westminster, on Wednesday, January 8th, 1919, Lieutenant-Colonel Alan H. Burgoyne, M.P., presiding.

The Chairman said it fell to the lot of all public men to have to take the chair on very many occasions, but he did not recall one that had given him greater pleasure than his being asked to take the chair that day. In the first place, they had the supreme advantage of having as the lecturer Mr. Handley-Page, than whom no one was better known in the annals of aircraft development, and the second reason was that that was a juvenile lecture, and the younger generation —the one next to himself—had come in their hundreds to listen to a subject which, he ventured to think, before the war would not have brought 20 of them. That was to say, the people of this country were beginning to realise the real essentials of what flying meant. A good chairman did not stand very long between the audience and the lecturer, but the audience would have to put up with him for five minutes, and after that they would be allowed to come over the top and throw bombs at him. With the increase of civilisation there was almost bound to be congestion. They desired to get on with commerce and trade, and so each nation, to get a little bit ahead of the other, covered the roads with every kind of mechanical contrivance and the seas with countless ships and under the seas with submarines, but there was one thing they had not tested—the vast upper spaces of the air. The time had come to develop them. The advantages were that there were no corners to go round, and there was nobody who did not know how to drive as well as yourself who need be on the same level. These were big, essential, and important advantages. Many of those present must have read the admirable address given by General Sykes, Chief of the Staff for the Air, in the Cannon Street Hotel on the previous day. He had pointed out what was going to be emphasised in the pictures to-day, that we were on to the aerial age. What he wanted to say particularly through the Press was that there had always been in the past a great disposition on the part of the living generation to disapprove of the improvements that were to be brought about for the sake of the generation that was to follow. In the early days of railway trains the farmers put trees across the tracks, and in the early days of motor-cars a man had to walk in front with a red flag. The man who invented the screw propeller, Sauvage, died of starvation. He wanted all the boys and girls who were there to buy books on the air and to study the coming means of getting about from one country to another. It would be a grand thing to have breakfast in London, luncheon in Paris, and dinner in Rome. He had interests in Africa and Australia, and he was going to fly there. That was the only civilised way to "get." One should not be frightened if there were accidents. There were bound to be some, but there was only one accident in every 1,200 hours flown. More people were killed by collisions with perambulators. We wanted to grow up accustomed to the facts of our new air. That was going to be brought home to them strongly to-day by Mr. Handley-Page. The aeroplanes that had gone to India had "blazed the trail." There was nothing in it. Planes could do much bigger distances, but they were the pioneers. Support the pioneers. The way of the prophet was hard, but that of the pioneer was simply ghastly. He had prophesied that there would be submarines when he lectured before the Royal United Service Institution in 1902. A critic wrote to him saying: "Give them up; they will all be on the scrap heap in 10 years." Here was a pioneer who had made

good, but for one Handley-Page who had succeeded a dozen might have made good if they had had public support. People should not be frightened by what seemed to them the miraculous possibilities of aircraft. A remarkable performance was that of an airship which recently went from Bulgaria to Central Africa to carry stores of munitions to the German troops, but did not deliver them as the Armistice had been signed, and that airship, with its load of munitions weighing 12 tons, went back to Bulgaria, having been in the air four days. It was sighted both ways across the Mediterranean at Malta. That was a big thing, but he believed that the aeroplane was going to do more. It was going to be big, safe, and foolproof. Ladies, and more particularly children, did not consider whether the taxi driver could drive. Look at the dangers if he bumped into something; but he did not. But a taxi driver could not drive an aeroplane. It required a great amount of knowledge of a number of things that could not come within the intelligence of a taxi driver. The air "liner" could carry a large amount of goods and have a great speed. The aeroplane thought nothing of 150 miles an hour, compared with about 20 travelled by the submarine under water, 40 by the fastest steamships, and about 80 by automobile. The coming race, which was the one that had to dictate to us, had to take an interest in this new development and to attend good lectures of this nature. He would count it as one of the gala days in his very tame career that he should have been asked as a member of the Council to take the chair on that occasion. They were fortunate in having Mr. Handley-Page there, and without any further words he would introduce him as one of the great successful pioneers in the most marvellous development that had taken place as the result of the war.

Mr. F. Handley-Page, C.B.E., then delivered the following lecture :—

"TO CONSTANTINOPLE AND BACK BY AEROPLANE IN WAR TIME."

After the inspiring remarks from the Chairman, my first thought as a manufacturer was that instead of lecturing I ought to address myself to him and endeavour to sell him an aeroplane.

I want to take you on a trip to Constantinople and to the East and India, and I hope what I have to say will not sound to those who are young like a lesson in geography—I don't want you to carry away the impression that you have been at school. I want you to travel across Europe on the magic carpet. Modern science has dispelled everyone's belief in fables and fairy stories, but we have in its place been given the most up-to-date marvel of the age, the aeroplane, which can take the place of the magic carpet or the seven league boots. The first picture shows one of these large machines on which the trip to Constantinople was taken. The machine measures 100ft. from tip to tip of the planes and 63ft. from nose to tail; on either side of the central body are the two engines. In the front a bomber sits, and he can release his bombs and drop them on objects below. But, unfortunately, when the bomber is about to drop his bomb, the enemy will not leave him alone. They attack him with hostile aircraft, guns, and such devices, so in the front there is fitted a gun, with which the bomber is able to keep off their attacks, and when he has dropped his bombs he often looses off a lot of ammunition at the people below. Behind here by that little window (indicated on the screen) is another gun, so that anybody who attacks the machine from the rear can also be fired at. The bombs are in the centre of the body, and are hung vertically. When the bomber in the front pulls his trigger the released bombs drop through here (shown on the screen).

The next machine shown is one of similar size in which Commander Savory, Captain McLennan, and Captain Rawlings, with an engineer and two air mechanics, flew from Hendon to Constantinople in 1917 to carry out a bombing

attack on the "Goeben," which was stationed there. These machines have two engines of 350 h.p. each.

The next is a bigger machine—the type which would have bombed Berlin if the Armistice had not been signed. If it did not bomb Berlin we may find consolation in the fact that perhaps the Germans knew it was coming and saw that it was time to give up. As in the previous case, the bomber sits in the front, and also has a gun which he can fire in all directions; behind him is the pilot and the captain of the vessel, and behind them again is the mechanic, who looks after all the engine equipment. On another platform at the back there are two gunners, one who fires upwards against hostile attack and another who fires downwards. Right at the tail of the machine there is another gun position, in which a man sits and fires back to beat off hostile attacks from the rear.

The map of Europe now shown indicates the route these people took on the journey to Constantinople. It goes from London to Paris, Marseilles, past the Bay of Spezia, Pisa, Rome, Naples, down at the foot of Italy, Otranto, across to Albania, where there are a lot of mountains, across to Salonika, and then across to one of the Greek islands, the Island of Mudros, to Constantinople. That journey was undertaken in 1917, but more remarkable flights have been tried with the same type of twin-engine machine to India, *via* Egypt. Those trips were taken along the same route to Otranto, and then, skirting the Island of Crete, they flew across the Mediterranean down to Cairo, where they waited some time, as they had big receptions and everybody wanted to see the machine. General Salmon, who was the Commander-in-Chief in that area, was taken on board, and they flew to Damascus and Baghdad and down to the Persian Gulf, and to Bunder Abbas and Guadar, Karachi in India, and Delhi, finally landing at Calcutta. That trip has also been taken since by a bigger machine such as you have seen with the four Rolls-Royce engines. They flew in bad weather on a straight course *via* Greece, across to Sicily, and then to Malta and across the Mediterranean, 700 miles, till they landed at railhead in Egypt. Over the South of Italy and on the Greek Islands at this time of the year the meteorological conditions are very bad. There are bad wind and rainstorms, and to avoid these they took a route curving round, instead of flying straight across as the smaller machines had done.

Travelling in the old-fashioned way, one would go on board ship—a means by which no self-respecting grown-up individual or youngster would want to go to the Continent nowadays—and the ship is seen in mid-Channel, and also the place where we land in France. The next pictures are Paris and a map of Europe, and, as seen from an aeroplane, the River Seine shows as a broad band in white, and on either side are trees and small houses. From the Seine we pass on to the Rhône, and we follow that river a long way in making our trip to Marseilles. In the next picture—also of the Rhône—a little bit of the rudder and elevators, at the back of the aeroplane, is visible. One sees so much of the river because it is a well-known landmark by which the pilot steered. We have left a town and are over the country, which looks like a draughtsboard, partly cultivated with corn and other crops and partly covered with trees. One takes photographs by just the same method in war time to observe the effect of dropped bombs on an enemy country, the only difference being that in the latter case you see little white marks with splashes out in all directions, which show where a bomb has been dropped and blown up a hole in the ground and scattered it.

The next picture shows a big stone bridge across the Rhône, and we follow the same river down to its mouth. Now we are just outside Marseilles. Rain was the cause of the cloudy effect. We now come to Marseilles itself, and have reached the sea. The picture shows the docks and ships and the little

houses dotted about. The rudder and tailplane of the machine can also be seen. The picture, which shows the docks and boats, public buildings and main roads, is such as an aeroplane would get if going to make an attack on Marseilles. It is a picture such as our submarine patrols would get. Another picture of the docks, showing the big quay and breakwater, and the long row of wharves along the front. Flying along the coast of the Mediterranean, we leave Marseilles and come to Italian territory. The next picture shows the Bay of Spezia. The next is a view taken at Pisa, which is famous for its leaning tower, which can be seen in the photograph. We are now coming to Rome, of which a picture is shown. The next shows the Pope giving his blessing in Rome. It can be seen that an enormous number of people came to this place in cabs drawn by horses. Anyone going on the trip to Constantinople in 1959 or 1989, instead of 1919, may witness a similar scene, but instead of cabs they may expect to see aeroplanes over the entire place. The following pictures are of a bridge over the Tiber and the banks. Those are photographs taken from the ground. The same places are now shown taken from overhead. We now come to Naples, which is not far from Vesuvius, the great volcano. The next picture, also of Naples, shows the Bay and the small boats, with the slopes of the mountains at one side. The next is another view of Naples, looking down on the town. Another picture shows the Bay of Naples again. That picture was taken in the machine. The propeller can be seen whizzing round and the lower plane and a vertical strut between the upper and lower plane. If you are close enough to the picture the little carriages can be seen and the people who are walking along the main street, 800ft. below. Further views are shown of Naples and the slopes of Vesuvius.

The photographs of Vesuvius are exceedingly interesting. A white patch shows the old crater which formerly vomited the lava and red-hot matter down the sides of Vesuvius. These photographs were taken by Major McLaren when flying to Egypt. The next is the crater, and the lines can be seen down which the red-hot lava pours and the sulphur smoke can be seen all white. Not content with taking a side view, they went nearer and looked down inside. The next view is looking right down into the crater. The lower part is all red-hot molten matter. If they had had an accident it would not have been pleasant to alight. Other pictures of the mouth and the side of the crater are shown. These are a remarkable set of pictures taken under conditions which I do not think any of us would like to undergo.

We now come down to Otranto, in the lower part of Italy, and the point where we leave Italy, and we are going across the Albanian Alps to Mudros. When Commander Savory and his expedition flew across here on their way to bomb the "Goeben" the country here was full of hostile horsemen. They could see them chasing round the lower parts of the hills, anticipating and hoping the engines would give out and that the machine would have to land. The machine flew over these mountains, which you see covered with snow, and on to Salonika, of which a view is shown, with the hospital encampment. This picture is taken from the rear position of the machine, looking forward. These two little pieces (indicated on the screen) are gun mountings, and the gun is for keeping off the enemy. Approaching the harbour at Mudros, you see the British gunboats lying there. They are now at the Island of Lemnos, preparatory to the final trip to Constantinople.

Commander Savory's trip was by no means a mere spectacular journey. They carried luggage, food, guns, spare ammunition, two spare propellers, a spare engine, three spare wheels, and three spare radiators—6½ tons in all. The attack on Constantinople was made by night, so I cannot show any pictures of Constantinople as they saw it, but when they got over Constantinople the lights were shining brilliantly and it was quite peaceful. They approached at 2,000ft.

up and then came down to 200ft., so that they could see all the shipping, and dropped all their bombs. The return journey was eventful, for part of one of the engines was shot away over Constantinople. I show some pictures of what Constantinople looked like before they went there.

To give an idea of the difficulties people have to undergo when they go bombing, I show a machine as it came back from Dunkirk, in France. A high-explosive shell had exploded under one of the wings. With the machine broken like that the pilot flew home from Dunkirk—60 miles—and landed safely. The fabric can be seen hanging down from the lower plane. All the ribs from a portion of the plane had been blown away, but happily neither of the main spars.

We will divert to the second trip made by Major McLaren to Egypt, branching off from the other route at Otranto, in the lower part of Italy, down to Greece. A photograph is shown of Kalamata, on the lower extremity of Greece, opposite to Crete. We now come to Suda Bay, from which they flew across to Egypt. This picture shows Suda Bay from the water; the next will show it from the air. The next picture is of the part of Alexandria where the machine landed, and in the next the machine is seen standing on the ground on its arrival. It has white cases over the propeller blades to prevent the heat warping them.

Cinematograph pictures were then shown, the first being one of the big four-engine machines flying, which, the lecturer remarked, Berlin would not have liked to have seen flying over it. The machine can lift 13 tons, and has carried 40 passengers in addition to the pilot. It is fitted with four 350 h.p. engines, equals 1,400 h.p., and the body is somewhat like a motor-'bus with wings fitted on either side. With a similar type of machine passenger services will be started, as soon as conditions permit the signing of the International Convention, by which people can travel in a short while all over the different parts of the globe. To the children who are here to-day the aeroplane will make a wonderful appeal. In times past we in this country have fired the imagination of our children—boys especially—by letting them read tales of pirates and treasure islands and wonderful Long John Silver, who was out to get all the money he could find. That firing of the imagination has led to the bringing up of our own generation keen to join our Navy and make it supreme on the sea. It is the same taste for adventure, the same desire to go to unknown lands and find hidden treasure and perhaps rescue helpless maidens who are being tortured, that feeling that St. George the Patron Saint of this country had, that I hope will also inspire all our youngsters in our generation to take to the air, so that they can make in a few days flights which will enable them to see these wonderful sights in Africa and all over the world. It is a delightful thought for the children that aeroplanes will make travel so much quicker that it will perhaps be possible to stay at home for holidays a day longer and still reach school in time.

This use of the air is really no new thing. Ever since the world began human beings have used the air to travel with. We are only going to do the same thing differently. We are not going to use water, in which we get drowned when we go underneath. We are going to use the air, which is our very breath of life. The aeroplane can bring distant people together, and it will effect as big a revolution in transport in this century as the electric telegraph made in communication during the last century. One feels moved to quote the text "For now we see as through a glass darkly, but then face to face." I think that expresses shortly how in the future we shall be able not merely to write or send a telegram to anybody and get a (perhaps mutilated) answer by telegram, but we shall travel in our aeroplane—no one will be more than about four days' distant—see our friends, and then come back after a pleasurable conversation.

This cinematograph picture showed the Handley-Page four-engine machine in its hangar, being brought out of the shed, the wings being unfolded and spread for flight, the machine taxi-ing across the aerodrome, turning on the ground under its own power, taking off, flying and landing.

Another cinematograph picture, "The Future in the Air," showed various incidents of a passenger trip from London to Paris, the carriage of mails from London to Manchester and Liverpool, and the dropping of a mailbag into a net by a machine during its flight.

The Chairman proposed a vote of thanks to Mr. Handley-Page. He hoped Mr. Handley-Page would keep them in touch year by year with the progress made. Possibly in 15 years, when a gathering such as that broke up, a mother with a Scotch family might say "Come on, children, don't keep the plane waiting. You know how your father hates you to be late for tea in Glasgow." He wanted to get three good holiday cheers for the lecturer, and these were given very heartily.

Dr. Thurstan proposed a vote of thanks to the Chairman (which was also given), and remarked that he was not like the chairman of a meeting who talked for hours and then called upon Dean Hole to give his address, to which the Dean replied that his address was "The Deanery, Rochester," and that he was "going there now."

ABRIDGMENTS OF RECENT PATENT SPECIFICATIONS (AERONAUTICS).

COMPILED BY MR. H. T. P. GEE, PATENT AGENT.

119,179. A. Evans, Plasnewydd, Cross Inn, Llanon, Aberystwyth. February 4, 1918.

Clinometers.—A clinometer for use on aircraft comprises a glass ball of spherical or oval form and one or more tubes extending therefrom. The ball and tubes are partially filled with liquid and are graduated by horizontal or radiating lines or combinations thereof.

119,251. C. S. Walker, The Limes, Roehampton Lane, Putney, London. July 12, 1917.

Framework.—Sheet metal frame members for use in aircraft are provided with bulged, fluted, or corrugated portions to strengthen them. The drawings show the front plate of an aeroplane body having a hole for the passage of the engine shaft. The plate has bulges and is flanged at the edges. Holes may be formed in the bulges for lightness. Where flutings or corrugations are formed they do not extend to the edges of the plates.

119,325. J. F. Monnot, 1, King Street, St. James', London. November 6, 1917.

Diaphragm Vibrators.—A warning or signal device suitable for large works or on aircraft comprises a number of diaphragms supported on a frame or casing adapted to be rotated relatively to a fixed wheel or cam. The casing is rotated by a shaft operated by an electric motor or other means or, if the device is for use in connection with aircraft, from a propeller shaft. According to the Provisional Specification, the casing may be fixed and the wheel rotated, or the casing and wheel may be rotated in opposite directions.

119,336. J. J. Murray, 42nd Street, New York, U.S.A. November 16, 1917.

Framework; Cars and Cabins.—The bodies of aeroplanes are built up of a number of hoops of wood, aluminium, compressed paper, etc., connected together by longitudinal tubes which are connected by diametrical braces of wire, etc., and screwed nipples passing through the tubes and hoops. The longitudinals are set flush with the hoops.

119,337. M. Phillips, 61, Lansdowne Road, Holland Park, and R. Temple, 13, Brewhouse Lane, Putney Bridge Road, both in London. November 19, 1917.

Hollow Laminated Articles.—Relates to the manufacture of laminated articles of wood veneer, etc., of a conical shape and suitable for use in the manufacture of vases and pots, aeroplane fuselage, tubular spars, etc. A series of shaped sheets are pressed in a hollow mandrel or mould, a layer of adhesive being placed between. For tubular spars, etc., a number of conical sections are placed one within the other in succession, and the ends may be completed by using sections of different lengths.

119,364. W. Taylor, 21, Tweed Street, Berwick-on-Tweed. January 2, 1918.

Levels and Clinometers.—A level for aircraft comprises a spherical vessel containing liquid and a pivoted buoyant indicator. The vessel is composed of a

glass or other transparent hemisphere bearing lines indicating the left, right, front, and rear, and also the degrees of tilt, and a hemispherical base of aluminium or other metal, the two parts being secured together by cement and a threaded locking ring bearing on a washer. The indicator is hollow, has a dome-shaped top bearing, a black or coloured central projection, and is mounted by a ball-and-socket joint on a member. This member is carried by a shaft screwed through the base of the level and by stays by which it may be adjusted so that the joint is in the centre of the sphere. Four-bladed resistances, to prevent motions in the liquid, may be provided on the shaft supporting the member and on the stays. A ring-shaped cushion of rubber may be provided to prevent damage to the indicator when the aircraft turns over, etc. The level may be secured to a tilting table on the aircraft which may be adjusted so that the level is accurately placed with respect to the aircraft. Reference is made to Specification 116,166.

119,375. S. E. Saunders, Ltd., and H. H. Thomas, Columbine Works, Medina Road, East Cowes, Isle of Wight. January 17, 1918.

Radiators for Aircraft.—The admission of air to aircraft radiators is controlled by one or more roller blinds consisting of articulated links or strips. Two such blinds, each covering half of the front of the radiator, may be drawn upwards in the guides by unwinding them from a spring roller by cords attached to a winding-drum. In a modified construction, the two halves of the blind are mounted on separate vertical spring rollers arranged at opposite sides of the radiator, and move horizontally to meet at the centre of the radiator. The blinds may be recessed at their meeting edges to pass round the propeller shaft of the motor.

119,380. C. Schoute, de Bilt, Utrecht, F. A. van Heyst, Soesterberg, and N. E. G. Meyer, Bosch en Duin, Zeist, all in Holland. January 28, 1918. Convention date, November 27, 1917.

Velocity Meters.—In apparatus for determining vertical velocities in or of air or water, specially applicable to aircraft and submarines navigated in a horizontally-moving medium, a shaft, rotating in a framing, pivoted on the body of the craft, carries a propeller and an armature rotating between the poles of a magnet pivoted always to remain vertical under gravity or other action. The current produced in the armature is taken off from the commutator and varies with the speed of the propeller and with the sine of the angle of inclination in the medium and thus provides a measure of the vertical velocity. The armature may be driven indirectly by the shaft.

119,392. A. H. Brackensieck, 8, Arden Road, Church End, Finchley, London. February 20, 1918.

Wire-Strainers.—Strainers for aeroplane, etc., stay wires are made of streamline form in cross-section, the forward and rear edges of the sleeve being arcs of small radius, while the sides are arcs of larger radius. The threaded members entering the sleeve may be eye, T-headed, shackle-ended, or other bolts as desired.

119,487. A. V. Roe, Avro Aerodrome, Hamble, near Southampton. July 17, 1917.

Screw Propellers.—In multiple-blade propellers for aircraft in which several blades with segmentally shaped roots are clamped together, the clamping bolts are arranged radially instead of transversely. In the application to four-bladed propellers the boss comprises four quadrants, and annular recesses formed in the assembled quadrants receive metal rings into which the securing bolts are screwed. These bolts have large washers under their heads and are prevented from becoming loose by plates fitted with serrated apertures screwed to the boss. The axes of

the bolts preferably lie in the planes of division between the boss segments. In the application to two-bladed propellers, the washers are replaced by hollow metal cups countersunk into the boss. For more than two blades, a washer-plate overlaps the edges of both adjacent boss segments and has inturned flanges which engage corresponding recesses in the faces of the segments.

119,707. J. H. Carson and G. H. Wade, B.E.F., France. October 12, 1917.

Steering and Balancing.—The gyroscopic action of an aeroplane propeller is utilised to effect adjustment of the propeller axis in any direction, a couple being applied to the propeller so as to cause it to precess into the desired direction. The elevator or aiderons may be adjusted simultaneously with the propeller. The drawings show a propeller rotatably mounted on a ring which may be adjusted in any direction on a fixed part-spherical member. The propeller shaft is provided with a universal joint, and the forces applied to the ring are conveyed to the propeller by means of a rib-and-groove connection. Rods connected to the ring are attached to cables leading to the control lever. The rods are passed through radial slots in brackets so as to prevent rotation of the ring. Fore-and-aft thrusts applied to the control lever are transmitted to the ring by means of an extension and certain of the cables which thereby apply a couple to the propeller causing it to precess about a transverse axis. Similarly, lateral pressure applied to the lever is transmitted by means of a yoke and the other cables to cause the propeller to precess about a vertical axis. Connections may lead to the elevators and ailerons. In modifications, the engine is mounted so as to be adjusted with the propeller. Specification 12286/09 is referred to.

119,726. F. Walton, Harford House, Beaulieu, Hampshire. October 24, 1917.

Framework; Planes, Construction of.—Struts, spars, ribs, etc., for aircraft are composed of a series of flexible tension elements such as wires passed through spacing-blocks which are separated by tubular compression elements fitted to the tension elements. The drawings show a structure composed of wires threaded through plates which are separated by members arranged on the wires. The whole may be clamped together by nuts on the ends of the wires. The plates may be of metal, wood, fibre, etc., and the members of bamboo, sheet metal, wood, etc. A wooden rod may be passed through holes in the plates. The plates may be corrugated or provided with web-like members. In a modification, longitudinal strips of metal may be secured together by bolts or rods with tubular spacing-pieces fitted on the bolts.

119,796. M. A. Aner, 8, Bridgewater Street, Liverpool. February 14, 1918.

Aerial Warfare.—Consists in protecting towns against aircraft attack by means of captive balloons, supporting nets, gun and searchlight platforms, dummy balloons, and telpherage lines for ammunition. Parachutes are provided as a means of safe descent in case of need.

119,837. W. R. D. Shaw, Danesbury House, Chingford Road, Walthamstow, London. May 30, 1918.

Aerial Machines with Aerostats; Aerostats; Cars and Cabins; Planes, Arrangement of.—An airship comprises a girder of T-form to which are attached aerostats. The girder is covered with fabric and serves to carry passengers, guns, etc., being fitted with a look-out, door, and windows or gun apertures in the sides of the horizontal portion. The rear end of the horizontal portion extends each side of the aerostat to form a tail-plane to which elevators are attached, the upper surface of the tail-plane being fitted with windows. Part of the girder forms a keel, to the rear end of which the rudder is hinged. The aerostats may be detachably connected to the girder by means of rings and safety hooks.

119,856. W. D. Warner, 8, East Broad Street, Columbus, Ohio, U.S.A. August 12, 1918, No. 13074. Convention date, October 4, 1917. Not yet accepted. Abridged as open to inspection under Sect. 91 of the Act.

Steering and Balancing.—The usual control lever of an aeroplane or other apparatus is fitted with a pair of pallets adapted to be gripped between the knees of the pilot to enable him to control the machine while having his hands free. The pallets are corrugated on their outer surface and are mounted on a sleeve provided with an inclined clamping screw so that the device may be secured to the control lever in any position. The drawings show the device applied to a wheel and oscillating yoke control, the pallets being clamped to an arm pivoted about the axis of the wheel to which it may be secured by a clamp.

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Four and Five-Engined Giant Aeroplanes. Illustrated. ("Aeronautics," November 20, 1918.)

Report on Gotha Bomber. Illustrated. With notes on giant aeroplanes. By the Technical Department of the Air Ministry. ("Aeronautics," November 20, 1918; "The Engineer," November 22, 1918.)

The Gotha Bombing Biplane. No. II. Illustrated. ("The Engineer," November 29, 1918.)

Design of Aeroplane Struts. W. H. Barling and H. A. Webb. Illustrated. ("The Aëronautical Journal," October, 1918.)

ABSTRACTS.

The Giant Aeroplane "Zeppelin."

The giant aeroplane, referred to in descriptions by the Press as "Lizenz," was brought down south-east of Soissons on June 4th, 1918. This aeroplane is supposed to have been constructed by the Albatros firm and to be a "Zeppelin" aeroplane. Many characteristics in the construction confirm this point of view, especially the use of aluminium in the ribs, in the tail plane, and elsewhere, and the similarity of the construction of these parts to that adopted in Zeppelins. To account for the construction by the "Albatros" works it is suggested that this machine was built under licence. Continuing, the article proceeds to point out that there is nothing inherently new in its construction except its immense size and the smaller aspect ratio of the wings, the general characteristics of its design being similar to the Handley-Page and other types of bombing machines.

The giant aeroplane, which has four motors in two tandem pairs, is very similar in general type to the A.E.G. double-motor type of bomber of 1916, except for the balancing of the controls. The use of triple rudders and biplane tail is also drawn attention to. Simplification in construction has been obtained by making the leading edges of the centre portions of the wings without any sweep back, and retaining a straight form for the trailing edges, which are normal to the centre line of the machine. Further, only the lower wings are set at a dihedral angle, and there is no stagger. The fuselage has also over a large portion of its length the same width of cross-section. Two eight-wheeled under-carriages, placed under the engines, support the aeroplane when on the ground with the help of a small two-wheeled under-carriage placed under the front part of the fuselage.

The crew consisted of some eight or nine persons. In the front of the fuselage there is a machine-gunner, and directly behind him the two pilots. Between the two mechanics, who are placed near the leading edge of the planes, and the two pilots there is doubtless situated an operator of the T.S.F. Between the tanks placed under the wings is a passage to the rear of the fuselage, where there are probably two machine-gunners in a special turret with facilities for firing downwards through an opening in the fuselage to the rear of the machine.

The writer of the article says the dimensions, etc., of the machine have been given erroneously by most journals, but that the figures given below are approximately correct:—

Dimensions in metres.—Total span of wings, 41 m.; chord at centre, 4.50 m.; chord at wing tips, 3.60 m.; maximum thickness, 0.22 m.; area of wings, 314.50^2 m.; ailerons, 7.10 m. by 1.02 m.; total area of ailerons, 14.50^2 m.; incidence of wing to axis of machine at centre line, 0.45 m. on 4.50 m. (at the wing tips this angle is decreased); front spars from leading edge at centre, 0.51 m.; rear spars from trailing edge, 1.51 m. and 1.005 m.; total length of machine, 22 m. (fuselage, 21.35 m.); area of fuselage at centre, 1.80 m. by 1.68 m.; nose of fuselage to leading edge, 4.75 m.

Engines from centre line of fuselage, 3.40 m.; distances of points of attachment of successive struts from centre line of fuselage: (1) 7.88 m.; (2) 13.08 m.; (3) 18.90 m.; distance apart on bottom plane of engine-bearing beams (front), 1.20 m., (rear) 2.48 m.; width of truck of two large under-carriages, 3.30 m.; of small under-carriage, 0.70 m.; height of fuselage above ground, 1.50 m.

Span of tail plane, 9.00 m.; chord at centre, 1.65 m.; maximum thickness, 112 mm.; chord of elevators, 0.44 m. at centre and 0.72 m. near the tips; gap of elevators, 2.15 m.; area of tail plane, 20^2 m., and elevators, 5^2 m.; area of each small lateral rudder placed 3.25 m. from central rudder 4^2 m. about.

The motors were four 250-300 h.p. Maybach engines with six vertical cylinders. The propellers (12 laminations) were 4.30 m. diameter. The radiator tubes are 0.20 m. thick by 0.40 m. by 0.85 m. long.

The height of the spars is as follows:—Front upper spar, 143 to 149 mm.; front lower spar, 140 to 144 mm.; rear upper spar, 162 to 167 mm.; rear lower spar, 161 to 155 mm.

These dimensions are maintained to within 0.6 or 0.7 m. of the wing tip; though on each side of the interplane struts the width of the spars, and not their height, has been thinned down by 6 mm. for almost a third of their length.

This width is normally as follows:—78 mm. for the upper front spar; 91 mm. for upper rear spar; 62 for the lower front spar; and 89 mm. from the lower rear spar.

The leading spar is parallel to the leading edge and the rear spar to the trailing edge. The ribs are placed perpendicular to the two last, and make an angle with the swept back leading edge of the wings. The spacing between the ribs, which is very great, varies between 0.565 m. and 0.43 m., and is least in the neighbourhood of the propellers. In the middle of the bay formed by the interplane struts two ordinary ribs are much closer together than the others, being 0.15 m. apart. They act as compression ribs to the secondary cross-bracing.

Except in the outermost bay there is a double cross-bracing of wires between the struts, consisting of cable varying in size from 2.7 c. to 2.4 c., attached to the spars of the interplane struts, and piano wire of 3 mm. joined to the ends of the twin ribs which are placed halfway between the interplane struts, as mentioned above. For the interplane bracing the longitudinal wires are fixed, but the transverse wires form an endless cable analogous to a system applied on the Zeppelin airships.

Ailerons are found on the upper wings only, and are of rectangular form. Their construction is entirely of metal: they are built up of steel tubes, with the ribs spaced at 0.50 m. apart.

The tail plane is a biplane of large span with the leading edges swept back, but with no stagger. The section is the same as that of the main planes, but it is reversed in position with an incidence of 0.17 m. on 1.57 m. The two spars of the tail plane are made of spruce and the ribs of poplar and spruce, similar in construction to those of the wings. The ribs of the elevators have the same cross-bracing construction as other ribs, but are made of duralumin of U section.

The rudders are mainly constructed of duralumin and the two lateral ones—trapezuim shaped—are partly balanced by areas placed in front of the hinges on which they turn.

The fuselage is of rectangular section, and shows the same general characteristics as older types of German fuselages in contrast with later types, which are monocoque. The upper longerons are of spruce and the lower of ash, each being composed of six pieces assembled as shown in the diagrams illustrating the article. The method of attachment of the cross-struts to the longerons and of the cross-bracing is also illustrated.

All the under-carriages of V type are of simple construction and need little

comment, except to note the enormous size (tube 110/120) of each of the axle trees carrying the eight wheels. (" L'Aérophile," August 1-15, 1918.)

Aeroplane Performance.

The relation of maximum and minimum speed to maximum altitude (ceiling) and to horse-power are explained and curves are given showing these relations. In one set of curves the engine or plane speed as a percentage of the speed near the ground is plotted against altitude. The maximum speeds are shown for engines having a mechanical efficiency of 100, 90, 80, and 70 per cent. The first is a horizontal straight line and the last drops rapidly with altitude. The minimum speed curves for various ratios of maximum to minimum are given, and rise with altitude. The intersection of the maximum and the minimum speed curves gives the " ceiling." Other groups of curves are engine and propeller power plotted against altitude, and ceiling height plotted against the ratio of maximum to minimum speed near the ground. Some important deductions are made from these various groups of curves; for instance, it is shown that a 10 per cent. decrease in mechanical efficiency of the engine reduces the ceiling by 4,000ft. There are suggestions in connection with lubrication of bearings in order to reduce friction. Suggestions are also made for supercharging by the compression of air supply, and as to the possibility of using steam-engines to obtain a greater ceiling height. (G. B. Upton, " Journal of the Society of Automotive Engineers," October, 1918.)

Physics of the Air.

In an appendix the wind velocity at a height of from 1 to 2 km. above the ground is considered, and lengthy tables are given, from which for certain latitudes between 25 deg. and 60 deg. and for various barometer gradients the wind velocity can be ascertained. This wind velocity is expressed in metres per second, kilometres per hour, and in miles per hour. Two sets of tables are given, one for cyclonic and the other for anti-cyclonic movements. (W. H. Humphreys, " Journal of the Franklin Institute," October, 1918.)

REVIEWS.

Mathematics for Engineers. Part I. By W. N. Rose, B.Sc. London: Chapman and Hall. 1918. 7s. 6d. 510 pp. Illus.

Mr. W. N. Rose takes his place in the directly useful series with two volumes of "Mathematics for Engineers," of which Vol. I. is here reviewed.

There are no special brands of mathematics suitable for different callings. There is merely mathematics and not mathematics. It is, however, permissible to select a body of applications arising from a special branch of science or technology and in this respect Mr. Rose's book is probably no worse than most. As a collection of problems arising in engineering it might be a very useful book in the hands of a teacher of adequate mathematical training. The attempt to combine, with this purely routine training, real mathematical teaching is a failure, though possibly not more lamentable than many others. If it is recognised that a student who had faithfully worked through the examples had not begun to be capable of the smallest departure in the way of original investigation, no great harm has been done.

A few examples are selected in which the idea, and inevitably the expression of the idea, is illogical and even ungrammatical.

(1) "*E.g.*, a chain hanging freely due to its own weight lies in a curve (known as the catenary)."

(2) "$\text{Log}_e N =$, $\log_{10} N \times \log_e 10$.

To remember this omit the logs and write the law in the practical

To remember this omit the logs and write the law in the fractional form

$$\frac{N}{e} = \frac{N}{10} \times \frac{10}{e}$$

which is equally correct as proved by cancelling" (?).

(3) "The Determination of Laws" (meaning the finding of empirical equations for tables or graphs).

(4) When $[x=a]\ L\,(x+a)^4 - x^4 = 4x^3$ is the abbreviation recognised for the statement.

"The limiting value to which the fraction $(x+a)^4 - x^4/a^4$ approaches as x approaches more and more nearly to a is $4x^3$." (!)

(5) "Plotting of Difficult Curve Equation

$$Y = \sin x" \ (!)$$

(6) "Alignment Charts are here explained in the fullest detail." (Only a very simple special case is actually discussed.)

(7) "*Series.*" The word "converge" appears once in this connection and incorrectly then.

(8) "In engineering practice one often meets with curves which are quite (?) periodic but are not of the sine or tangent type." The reviewer would like to meet an engineering curve of the periodic tangent type, and one not "quite" periodic.

Quadratics are divided into three types, "pure," "adfected" and "general.

It would be interesting to ascertain a conscientious student's conception of functionality, continuity, limiting values, convergency, etc., after working through this book.

A.R.L.

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